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AN ANNOTATED BIBLIOGRAPHY OF THE OPTICAL PROPERTIES OF AGRICULTURAL PRODUCTS

By
Gerald S. Birth
Instrumentation Research Laboratory
Market Quality Research Division
Agricultural Research Service
United States Department of Agriculture
Beltsville, Maryland

This bibliography was prepared to assist technical people in finding data on the optical properties of agricultural products. References included are those which contain basic data on the optical properties of unprocessed agricultural products. These are defined as reflectance, transmittance, fluorescence or phosphorescence vs. wavelength data and index of refraction data. Generally, references having data consisting of measurements at one or two specific wavelengths are not included. However, references containing tristimulus color data are included because much of the data on color of agricultural products has been obtained with tristimulus instruments. Some references are included on juices and meats where limited processing is necessary to make the measurement.

A few references, giving data on specific organic substances, are included as well as references to extensive bibliographies in this area.

Areas which should be explored for more references:

Flowers

Skins, hides, hair, pelts, etc.

Phosphorescence

References in the paper by Gates

The letter in parenthesis at the end of the notation defines the type of data to be found in the reference according to the following code:

R - Reflectance

T - Transmittance

F - Fluorescence

P - Phosphorescence

I - Index of Refraction

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1. Altman, Philips L. and Dittmer, D. S. Biology data book, Federation of American Societies for Experimental Biology. Washington, D. C. 615 p. 1964.

   A revision of Handbook of Biological Data by Spector published in 1956. (I)

2. Asen, S. A rapid method for evaluating the color or Hydrangea macrophylla sepals. Proc. Amer. Soc. Hort. Sci. 74:677-680, 1959.

   An objective method for evaluating the color of hydrangea sepals is described. Differences that were difficult to see with the eye were resolved. The ratio of the percent reflectance at 630 and 430 mμ served as the index. Reflectance curves of three flowers in the 400 to 700 mμ region are included. (R)

3. Association of Official Agricultural Chemists. Offical methods of analysis. 9th ed. Washington, 1960. 832 p.

   Data on the refractive index for sugar solutions, oils, fats, and waxes are given. (I)

4. Birth, Gerald S., Norris, Karl H., and Yeatman, John. Non-destructive measurement of internal color of tomatoes by spectral transmission. Food Technol. 11: (11) 552-557, 1957.

   The color of tomato juice can be predicted by making a light transmittance ratio $\frac{T\ 620\ m\mu}{T\ 670\ mu}$ measurement on intact tomatoes prior to juicing. Transmittance curves of three tomatoes at various stages of color development are included. (T)

5. Birth, G. S. A nondestructive technique for detecting internal discolorations in potatoes. Amer. Potato J. 37: (2) 63-60, 1960.

   Light transmittance was used to develop a method for detecting internal discolorations in potatoes. The index of the defect is the optical-density difference between the energy transmitted at 800 mμ and 750 mμ. Includes data on transmittance of two potatos for the 600 mμ to 900 mμ spectral region. (T)

6. Birth, G. S. Measuring the smut content of wheat. Trans. Amer. Soc. Agr. Eng. 3:(2) 19-21, 1960.

A method for objectively measuring the smut content of wheat was developed, that is, the difference in optical density of a sample of bulk wheat at 800 mμ and 930 mμ. An instrument developed to make this measurement is described. A transmittance curve of a sample of bulk wheat for the near infra-red spectral region is included. (T)

7. Birth, Gerald S. and Olsen, Kenneth L. Nondestructive detection of water core in Delicious apples. Proc. Amer. Soc. Hort. Sci. 85: 74-84, 1964.

Five methods of detecting water core nondestructively are described and compared. The best results were obtained with an optical-difference measurement. [Δ O. D (760 nm - 810 nm]. Transmittance curves of a sound apple, water-cored apple, and an apple with internal browning are included. (T)

8. Brant, A. W., Norris, K. H. & Chin, Gilbert. A Spectrophotometric Method for detecting blood in while shell eggs. Poultry Science 32(2): 357-362, 1953.

The spectral characteristics of intact eggs and egg components were determined. The presence of blood increased the absorbtion of energy at 575 mμ. By scanning a relatively narrow spectral region (565 to 585) it was possible to detect blood in intact eggs with an accuracy of 97.5%. (T)

9. Breasley, N., Breeze, J. E., and Cuthbert, R. M. The production of a standard comparator for the skin color or mature cherries. Food Technol. 18: (9) 231-233, 1964.

Spectral reflectance measurements were made of the skin colors of mature cherries of the Bing and Lambert varieties. These results were used to develop standard color comparators for use in the field. (R)

10. Brissey, George E. Factors affecting stability of meat pigments. 16th Annual Reciprocal Meat Conference. Proceedings, p. 97-101, 1963. Publ. by National Livestock and Meat Board, Chicago.

Sanitation, temperature, drying, packaging, freezing and lighting are discussed as they affect meat color. (R)

11. Burton, H. Color changes in heated and unheated milk. V. The effects of temperature of measurement, pH, and the addition of certain ions on the reflectance of separated milk. J. Dairy Res. 23: (1) 92-104, 1956.

Changes in the reflectance of milk in the 4000 A. to 7000 A. spectral region were related to temperature and pH. (R)

12. Butler, W. L., and Norris, K. H. Plant Spectra: Absorption and Action. In Modern Methods of Plant Analysis. Vol. V: 51-72. Springer-Verlag, Berlin. 1962.

Techniques for obtaining and interpreting spectral transmittance curves of intact biological materials are presented. Representative data of samples of wood (4-cm thickness) apple flesh, tomato puree, a green leaf, and a peanut at several stages of germination are included. (T)

13. Butler, Warren L. Absorption of Light by Turbid Materials. J. Opt. Soc. of Am. 52 (3) 292-299, 1962.

The effect of light-scattering substances on absorption spectra is discussed theoretically with supporting experimental data. This information aids in relating absorption spectra of pigments in a product to the data obtained by making transmittance measurements of the intact product. (T)

14. Color in foods; a symposium. Advisory Board on Quartermaster Research and Development. Natl. Acad. Sci., Natl. Res. Council, Washington, D. C., 1954. 186 p.

Most of the presentations discuss abridged instruments for making rapid evaluations of the color of foods. Both tristimulus instruments and instruments for measuring at specific wavelengths are included. Most applications are for measuring color of tomatoes. Data on cherries and several processed foods are included. (R)

15. Denisen, E. E. Tomato color as influenced by variety and environment. Proc. Amer. Soc. Hort. Sci. 51: 349-354, 1948.

A study was made to determine the factors responsible for variation of color in tomatoes and to determine the effects of different varietal and environmental conditions on color development. The effects of light on red tomatoes, as shown by measurements of shaded and exposed fruits, were highly significant for some varieties. Color was measured with tristimulus color instruments. (R)

16. Eastmond, E. J. Measurement of Color Changes in Foods. Analytical Methods in the Food Industry #3. Advances in Chemistry Series 3-12, 1950.

Methods are described for determining how well the original color of food is preserved in processing and storage. Data on corn, lemons, peas, and frozen peaches for the 400 mμ to 750 mμ spectral region are included. (R)

17. Fox, K. K., Holsinger, V. H., and Pallansch, M. J. Fluorimetry as a method of determining protein content of milk. J. Dairy Sci. 46: (4) 302-309, 1963.

A spectrophotofluorimeter was used to determine the relationship between the intensity of the fluorescence of milk in the ultraviolet region and its protein content. Light in the 280 mμ region was used to excite a fluorescence at 340 mμ. (F)

18. Francis, F. J. A method of measuring the skin color of apples. Proc. Amer. Soc. Hort. Sci. 60:213-220, 1952.

Describes a device used to rotate an apple while the color is being measured on a tristimulus color difference meter. This technique is used to secure an expression of the average color of fruit. (R)

19. Francis, F. J. Color and pigment measurement in fresh cranberries. Proc. Amer. Soc. Hort. Sci. 69:296-301, 1957.

Methods for measuring the pigment content and surface color of fresh cranberries are described. A tristimulus measurement of color is used to assay the surface color. Data on three varieties are included. (R)

20. Francis, F. J. Relationship between flesh color and pigment content in squash. Proc. Amer. Soc. Hort. Sci. 81:408-414, 1962.

Small sections of squash were cut and the color of flesh measured on a tristimulus color instrument. Data were secured with two instruments. Pigment concentrations are presented also. (R)

21. Francis, F. J., and Servadio, G. J. Relationship between color of cranberries and color and stability of juice. Proc. Amer. Soc. Hort. Sci. 83:406-415, 1963.

Color of fresh cranberries as measured with a tristimulus color instrument was correlated with pigment content and juice color. (R)

22. Francis, F. J. Cranberry color measurement. Proc. Amer. Soc. Hort. Sci. 85:312-317, 1964.

An Agtron Model H Colorimeter, a Colormaster Differential Colorimeter, and a G. E. Spectrophotometer are compared in correlating reflectance data with pigment content of cranberries. Spectral reflectance curves (400 mμ to 700 mμ) of fresh cranberries at five stages of color development are included. (R)

23. Gates, David M., Keegan, Harry J., Schleter, John C. and Weidner, Victor, R. Spectral Properites of Plants. Applied Optics. 4:(1) 11-20, 1965.

The spectral properties of plant leaves and stems were obtained for the ultraviolet, visible and infrared. Data are presented in percent reflectance, absorption and transmittance curves. Data cover a very wide spectral region. (R)

24. Haas, Martin C. and Bratzler, L. J. Determination of Myoglobin Oxygenation rates in pork, beef, and lamb by Munsell and reflectance colorimetry. Journal of Food Science 30:(1) 64-68, 1965.

Tristimulus color measurements of meat were made at several increments of time from immediately after cutting to 24 hours. An index of reddening was developed from the color data and plotted against time. (R)

25. Hand, David B., et al. The yield and quality of juice obtained from New York state tomatoes graded according to United States Department of Agriculture standards. New York Ag. Exp. Sta. Bull. 759, 1953. 66 p.

An extensive investigation of factors affecting color and quality of process tomatoes was made. Color was measured with a tristimulus instrument and correlated with visual scores, harvest data, and processed juice color. (R)

26. Handbook of chemistry and physics. 45th ed. The Chemical Rubber Co., Cleveland, 1964.

The index of refraction is given for a large number of organic compounds. (I+R)

27. Hershenson, Herbert M. Ultraviolet and visible absorption spectra; Index for 1930-1954. Academic Press, 1956. 205 p.

This first volume contains about 32,000 references to published absorption spectra in 27 important American and European journals. Although data on intact agricultural products are not included, there are references to spectra of organic compounds, oils, etc.

28. Hershenson, Herbert M. Ultraviolet and visible absorption spectra; Index for 1955-1959. New York, Academic Press. 1961. 133p.

29. Hershenson, Herbert M. Infrared Absorption Spectra Index for 1945-1957.

This Volume contains about 16,000 references to published absorption spectra in thirty three important American and European journals.

30. Hollaender, Alexander ed. Radiation Biology Vol. III. Visible and Near-Visible Light. Maple Press Co., York, Pa. 1956.

Chapter 6. The Absorption, Action and Fluorescence Spectra of Photosynthetic Pigments in Living Cells and Solutions.

Methods of making spectrophotometric measurements of intact plant tissue are discussed. Data on the reflectance, transmittance and absorption of leaves are included for the 400 mμ to 700 mμ spectral region. Also spectrophotometric and fluorescence data on many photosynthetic pigments are included. (R, T&F)

31. Jacob, F. C., Romani, R. J., and Sprock, C. M. Fruit sorting by delayed light emission. Amer. Soc. Agr. Eng. Paper No. 63-814. 1963.

Experimental evidence showed that delayed light emission can be used as a measureof surface chlorophyll concentration, and hence, as a measure of maturity for some fruit. (P)

32. Jacobs, Morris B. The chemical analysis of foods and food products. 3rd ed. D. Van Nostrand Co., Princeton, N. J., 1958.

Application of the refractive index to measuring soluble in foods is discussed using both the Abbe refractometer and the immersion refractometer. Data on sucrose solutions are included. (I)

33. Jenness, Robert and Patton, Stuart. Principles of dairy chemistry. John Wiley & Sons, New York, 1959. 446 p. (Physical properties of milk--Refractive Index, p. 254-257)

Discusses the refractive index and its application to the measurement of soluble solids in milk. Data relating refractive index and total solids are presented. (I)

34. Kramer, A., and Smith, H. R. Electrophotometric methods for measuring ripeness and color of canned peaches and apricots. Food Technol. 1:527-539, 1947.

Results of spectrophotometric and fluorometric methods for the quantitative measurement of extractable pigments from peaches and apricots are presented and correlated with ripeness and color as judged by organoleptic methods. (T)

35. Little, A. C., Chichester, C. O., and Mackinney, G. On color measurement of foods. Food Technol. 12(8):403-409, 1958.

Five spectrophotometers and three tristimulus photoelectric colorimeters were compared. Results from theee different makes of colorimeters were placed on a comparable basis by regression equations. Samples compared are colored paper and pea puree. (R)

36. Lukens, H. C., MacKenzie, R. P., and Kunsman, C. H. Color-moisture relations of yellow sweet corn. J. Ass. Offic. Agr. Chem. 37(2):489-499, 1954.

Spectrophotometric data and tristimulus measurements are correlated to the moisture content of sweet corn. A description of an abridged photometer for making rapid color evaluations of corn is included. (R)

37. Lukens, H. C., and Kunsman, C. H. Effect of scalding on the color-moisture relations of yellow sweet corn. J. Assoc. Offic. Agr. Chem. 38(3):783-792, 1955.

Spectral reflectance curves and tristimulus data are given for both raw and scalded yellow sweet corn. Higher purity and lower lightness accounted almost entirely for the color difference between scalded and raw yellow sweet corn of like moisture content. (R)

38. Lukens, H. C., and Palmer, K. J. Spectrophotometry of yellow sweet corn. Food Technol. 10(4):190-193, 1956.

Reflectance curves of yellow sweet corn are presented for the 400 to 700 nm region. Changes in reflectance as related to moisture content are given also. The data are used to develop an index of corn color; i.e. $\frac{T445nm}{T520nm} \neq \frac{T585nm}{T520nm}$

This index is correlated with moisture content, with a standard error of estimate of 2% moisture. (R)

39. Lott, V. Richard. Variability in color and associated quality constituents in Golden Delicious apple packs. Proc. Amer. Soc. Hort. Sci. 83:139-148, 1963.

A study was made of the variability in color and quality in some commercial packs of Golden Delicious apples. Spectral reflectance curves showing the range in skin and flesh color are included. Tristimulus data as related to other quality factors are included. (R)

40. Lott, R. V. Some spectral curves of maturing apples. Proc. Amer. Soc. Hort. Sci. 43:59-62, 1943.

Reflectance data of 11 apple varieties are presented, with curves and tabular data for both skin and flesh. Covers the spectral region from 400 mμ to 700 mμ. (R)

41. Lott, R. V. A spectral analysis of color changes in flesh and skin of maturing Grimes Golden and Stayman Winesap apples. Proc. Amer. Soc. Hort. Sci. 44:157-171, 1944.

Reflectance curves and tabular data of two varieties of apples at several stages of maturity are shown. Some transmittance measurements, of the peel, and thin sections of the flesh are included. (R)

42. Massie, D. R., and Norris, K. H. The spectral reflectance and transmittance properties of grain in the visible and near infrared. Amer. Soc. Agr. Eng. Paper 64-803. Presented Dec. 1964.

Spectral reflectance curves of oats, corn, alfalfa seed, rice, wheat and soybeans are given for the .4 to 2.0 micron region. Additional reflectance and transmittance curves of several grains at various moisture contents in the 1.0 to 2.0 mμ region are included. Data were secured with a specially designed spectrophotometer. (R & T)

43. Mackinney, G. and Little, A. C. Color of foods. Avi. Publ. Co., Westport, Conn., 1962. 308 p.

The book indicates how color is used as a criterion of maturity of crops and as an indicator of quality control during processing. Reflectance measurements of different commodities are discussed. Some data on purees and meats are included. Contains about 340 references. (R)

44. Moss, R. A. and Loomis, W. E. Absorption spectra of Leaves. I. The visible spectrum. Plant Physiol. 27(2):370-391, 1952.

Spectral characteristics of plant leaves were determined by measuring light reflected and transmitted by leaves. Data on about twenty different plants are presented as reflectance and absorption curves for the 400 mμ to 700 mμ region. (R)

44a. Nickerson, Dorothy. A method for determining the color of agricultural products. U.S. Dept. of Agr. Tech. Bull. 1954, 1929.

The problem of measuring color of agricultural products is discussed. Development of a method for measuring color of cotton includes data on percent reflectance curves for cotton. Tristimulus measurements of color of cotton and some other products are included. (R)

45. Nickerson, Dorothy. New automatic cotton colorimeter for use in cotton quality specification. Textile Res. J. 21(1):33-38, 1951.

An abridged instrument developed to provide an objective evaluation of cotton color is described. Data are presented as examples of the use of the instrument. (R)

46. Nickerson, Dorothy. Color measurement and its application to the grading of agricultural products; a handbook of the method of disk colorimetry. U.S. Dept. Agr. Misc. Pub. 580, 1946. 62 p.

The importance of color in grading agricultural produce and methods of measuring color are discussed. Data on the color of a number of products; cotton, meat, wheat, foliage, soil, and tomato pulp are given in percent reflectance vs. wavelength curves and in tristimulus measurements. (R)

47. Nickerson, Dorothy, and Tomaszewski, Josephine J. Color change in raw cotton related to conditions of storage. Textile Res. J. 28(6):485-497, 1958.

Changes in the color of cotton (yellowing) due to adverse storage conditions are shown. Data were secured with a cotton colorimeter. (R)

48. Norris, K. H. Measuring Light Transmittance Properties of Agricultural Commodities. Agricultural Engineering 39(10):640-643 & 651, 1958.

Instrumentation and technique are described for measuring the light transmittance properties of Agricultural products. Data on apples, ground beef and peaches are included. (T)

49. Norris, K. H. Photoelectric inspector detects green-rot in eggs. Electronics 28:(7)140-142, 1955.

A method for nondestructively detecting bacterial spoilage inside eggs is described. Spectral fluorescence curves of sound and infected (both white and brown shell) eggs are included. (F)

50. Norris, K. H., and Rowan, J. D. Automatic detection of blood in eggs. Agricultural Engineering 43(3)154-159, 1962.

A criterion for the automatic detection of blood in both brown and while shell eggs is given. Absorbancy curves of an egg with and without blood are shown for a limited spectral region. Includes absorbancy curves of egg shells also. (T)

51. Norris, Karl H. Design and development of a new moisture meter. Agr. Engin. 45(7):370-372, 1964.

Spectrophotometric curves in the spectral region from .9 to 2.5 mμ are presented for ground wheat with three different moisture contents. These data are used to develop an objective index of moisture. An instrument designed to make this measurement is described. (T)

52. Oster, Gerald, and Pollister, Arthur W., eds. Physical techniques in biological research, Vol. 1 - Optical techniques. Academic Press Inc., New York, 1955. 564 p.

This book contains much information on optical techniques in research. Spectrophotometric data of many organic compounds are included, as well as references and a guide to literature searching. (T)

53. Palmer, J. Electronic sorting of potatoes and clods by their reflectance. J. Agr. Eng. Res. 6:(2)104-111, 1961.

The reflectance characteristics of several potatoes were plotted for the 3000 A to 10,000 A region. A ratio of the reflectance in the red (8000 A to 9000 A) part of the spectrum to the blue (3250 A to 4000 A) was used as an index to distinguish between soil clods and the potatoes. (R)

54. Parker, B. F., and Wiant, D. E. Efficiency of visual-manual cherry sorting. Agricultural Engineering 36:(2)100-105, Feb. 1955.

The color of red cherries at various stages of maturity, with and without defects, was analyzed to develop optimum lighting conditions for sorting. Includes spectral reflectance data for cherries in the 400 to 700-mμ spectral region. (R)

55. Potts, F. J., and Fong, W. Economic evaluation of color in domestic wool. U. S. Dept. of Agr., Market Res. Rep. 204, 1957. (Processed)

Color as a quality factor in wool is discussed and compared with other factors. Data on about 80 samples of wool are presented. The color measurements were made with a tristimulus color instrument. A color comparator was developed with the data. (R)

56. Powers, J. B., Gunn, J. T., and Jacob, F. C. Electronic color sorting of fruits and vegetables. Agricultural Engineering 34:(3)149-154, 158, 1953.

A machine was developed for color sorting of fruits and vegetables based on the Index of Variance in Reflection (IVR). The index was established by the reflectance from the sample of light at two different wavelengths. (R)

57. Rabinowitch, E. I. Photosynthesis and related processes. Interscience Publ., Inc., New York, 1945-1956. 2 vols.in 3.

Light absorption by pigments in the living cell. V.2, pt. 1, 672-736; V.2, pt. 2, p. 1841-1867.

Fluorescence of pigments in vivo. V.2, pt. 1, p. 805-826.

Spectroscopy and fluorescence of pigments. V.2, pt. 2, p. 1793-1882.

The role radiation plays in the photosynthesis process is discussed in considerable detail. There are data on chlorophyll and related pigments. In addition, appreciable spectrophotometric data on living plants are included. Most of the information is for the ultraviolet and visible spectrum. (T, R & F)

58. Radley, J. A., and Grant, Julius. Fluorescence analysis in ultraviolet light. (A series of Monographs on Applied Chemistry, Vol. 7, 4th ed.) Chapman & Hall Ltd., London, 1954, 560 p.

Applications of fluorescence analysis to agriculture, bacteriology, botany, drugs, food and food products, leather, paper, rubber, and textile industries are discussed. Contains more than three thousand references. (F)

59. Ramakrishnam, C. V., and Banerjee, B. N. Studies on the refractive index of milk. Indian J. Dairy Sci. 5:(1)25-31, 1952.

The effect of feed, acidity, processing, addition of skim milk, water and sucrose to milk on its density, refractive index and refractive constant was determined. Addition of water or skim milk to whole milk, and sugar to watered milk lowered the refractive index of milk. (I)

60. Romani, R. J., Jacob, F. C., and Sprock, C. M. Studies on the use of light transmission to assess the maturity of peaches, nectarines and plums. Proc. Amer. Soc. Hort. Sci. 80:220-229, 1962.

Through a selection of specific wave lengths it is possible to discern changes in light transmission characteristics of fruit which correspond to changes in maturity. Ratios of light transmission at approximately 730 and 850 mμ were shown to be useful in following the maturity of 8 varieties of peaches and 7 varieties of nectarines. (T)

61. Romani, R. J., Jacob, F. C., Mitchell, F. G., and Sprock, C. M. Light transmittance characteristics of maturing apricots. Proc. Amer. Soc. Hort. Sci. 83:226-233, 1963.

The light transmission characteristics of whole apricots have been determined. A ratio of the light transmitted at 590 and 650 mμ indicated potential as a measure of apricot maturity. (T)

62. Romani, R. J., et al. Light transmission characteristics of fruit as indices to fruit maturity. Int. Hort. Cong., 16th Cong., V. 3:337-342. 1962, pub. 1963.

Possible approaches to evaluating maturity of fruit with light transmittance are discussed. Transmittance curves of plums, apricots and nectarines at two stages of maturity are included. (T)

63. Rood, Paul. Development and evaluation of objective maturity indices for California freestone peaches. Proc. Amer. Soc. Hort. Sci.70:104-112, 1957.

In a test comparing several methods of estimating maturity of freestone peaches, ground color and flesh color were reported to be the second and third best indices of maturity (after pressure). Reflectance curves were recorded for several peaches (Hale and Elberta varieties) to establish maturity standards. (R)

64. Ross, Edward, Brekke, J. E., and Moore, J. F. The objective evaluation of some green bean varieties used for processing in the Northwest. Proc. Amer. Soc. Hort. Sci. 67:398-411, 1956.

Several varieties of Blue Lake beans were evaluated for processing quality factors; i.e., fiber content, tough string count, and color. Color was expressed by measuring the transmittance of an acetone extract and by a tristimulus measurement on the intact beans (fresh and processed). (R)

65. Servadio, G. J., and Francis, F. J. Relation between color of cranberries and color and stability of sauce. Food Technol. 17:(5) 124-128, 1963.

Data obtained with tristimulus color instruments are used to relate the surface color of fresh cranberries to the pigment content and the color of the processed product. (R)

66. Sevcik, V. J., and Sunderland, J. E. Emissivity of beef. Food Technol. 16:(9)124-126, 1962.

A procedure for measuring the emissivity of foods is described. Data on the emissivity of beef fat and lean beef muscle are given for the temperature range of 60° to 100°F. (E)

67. Sidwell, A. P., Birth, G. S., Ernest, J. W. and Golumbic, C. The use of light transmittance techniques to estimate the chlorophyll content and stage of maturation of Elberta peaches. Food Technol. 15(2):75-78, 1961.

A criterion for estimating the maturity of peaches is described. This criterion is based on an optical-density difference measurement; i.e., Δ O.D. (700-740). Spectral transmittance curves of peaches varying from extremely immature fruit to tree-ripened stages are included. (T)

68. Spector, William S., ed. Handbook of biological data. Saunders, Philadelphia, 1956. 584 p.

An extensive compilation of data (445 tables) on physical properties of biological materials. (F, I)

69. Stermer, R. A., et al. A rice photometer for measuring the degree of milling of rice. Rice Journal 65:(5)22-29, 1962.

The photometer measures the transmittance of a rice sample at 850 Mμ and 660 Mμ. The ratio between these measurements is the index of degree of milling. Transmittance curves of five samples of rice for the spectral region 500 Mμ to 1000 Mμ are included. (T)

70. Sul'gin, I. A., Klesnin, A. F., and Podol'nyz, V. Z. The optical properties of plant leaves in the ultraviolet region. Fiziologiya Rastenyi 792:116-118, 1960. (T & R)

Transmission, reflection and absorption of light (in the 330 to 440-mμ wavelength region) by mature leaves were studied in some mesophytic and xerophytic ornamental plants. (T & R)

71. Tinsley, I. J., Sidwell, A. P., and Cain, R. F. Methods of presenting raspberry and strawberry samples to the Hunter color and color-difference meter. Food Technol. 10:(8)339-344.

A method of measuring color of small berries with a tristimulus color instrument is described. A transparent container holding the sample rotates at about 100 rpm directly over the viewing window of the instrument. The procedure eliminates the need for making repeated measurements of a sample which varies considerably in color. (R)

72. Triebold, Howard O., and Aurand, Leonard W. Food composition and analysis. New York, Van Nostrand, 1963. 497 p.

Discusses use of the refractive index to measure the concentration of sugar solutions. The Index of refraction is given for oils, fats, serums and sucrose solutions. (I)

73. Tollin, G., Fujimori, E. and Calvin, M. Action and emission spectra of the luminescence of green plant materials. Nature 181:1266-1267, 1958.

A study of the spectral characteristics of the delayed light emission of green plant materials was conducted. The intensity of the emitted light, approximately 0.2 sec. after excitation by the flash, was measured at 10 mμ intervals. (P)

74. Udenfriend, Sidney. Fluorescence assay in biology and medicine. Academic Press, New York, 1962. Third printing, 1964 with literature appendix 1962 through 1964. 517 p.

This book contains information on principles of fluorescence and methods of analysis. Considerable data on organic compounds are included. (F)

75. Worthington, Oliver J., Cain, Robert F., and Wiegand, Ernest H. Determination of color of unclarified juices by reflectometer. Food Technol. 3:274-277, 1949.

A device for measuring the color of juices with a tristimulus photometer is described. Data on the color of twenty different juices are presented. (R)

76. Yeatman, J. N., Sidwell, A. P., and Norris, K. H. Derivation of a new formula for computing raw tomato juice color from objective color measurement. Food Technol. 14:16-20, 1960.

An index of tomato juice color was developed employing a tristimulus color measurement. The formula was developed to give the best relation to visual scores of juice color. (R)

77. Yeatman, J. N., et al. Spectrophotometric evaluation of anthocyanin pigment development and scald damage in intact red cherries. Food Technol. 15:(12)521-525, 1961.

Development of indexes for evaluating the color and scald damage of intact red tart cherries. Curves of cherries at several levels of color development as well as a cherry with and without scald are shown. (T)

78. Zitnak, A., Franklin, E. W., and Czaja, C. A. The evaluation of visual and photoelectric means of fresh tomato colour rating as related to colour quality. Canadian committee on fruit and vegetable preservation. Report 1958:21-22. Canada. Dept. of Agriculture, Ottawa, Canada, 1959.

Color of the cut surface of tomatoes was measured and compared with a color index based on a tristimulus color-measuring instrument. (R)